A Study of the First Global Measurements of the Water Cycle (NEWS/04-2-0000-0020)

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ABSTRACT: Water storage changes in Earth's land, ocean, atmosphere and ice reservoirs vary on time scales ranging from instantaneous to geologic. As such they represent a fundamental and interactive component of the climate system. Until recently, the lack of a consistent, single monitoring framework has hampered efforts to track shorter-term human time scale variations (e.g. monthly, seasonal-interannual (S-I) and decadal-scale) of these storage changes, which are essential for enhanced weather and climate prediction, and for monitoring global change impacts on the hydrologic cycle. Consequently, no comprehensive, modern picture of the stocks and fluxes of the global water cycle currently exists. The recent launch of the Gravity Recovery and Climate Experiment (GRACE) satellite mission offers a tremendous new opportunity to monitor water storage changes in Earth's major reservoirs: it is now possible for the first time to begin comprehensive assessment and analysis of mass movements in the global water cycle using one observing system. Here we propose to use primarily GRACE observations of time-variable gravity (in conjunction with other sensors and data sets as appropriate) to provide a first global, comprehensive assessment of monthly water storage changes in Earth's ocean, ice, land and atmosphere reservoirs. While the major emphasis of the proposed work is on estimating and understanding storage changes, a second goal is to characterize the range of flux estimates of precipitation and evaporation between the storage reservoirs from numerical weather prediction (NWP) models like ECMWF, and to determine their consistency with the GRACE-derived storage changes. Third, we will identify the spatial-temporal distribution of source/sink regions of fresh water in the global water cycle by analyzing global patterns of mass changes from GRACE in conjunction with our flux estimates and those of water vapor divergence/convergence from the NWP models.

An important implication of the proposed work is that for the first time, we now have global, uniformly connected measurements of water mass movement in the Earth system. From these measurements we will develop a new conceptual understanding of the stocks and fluxes of the global water cycle, including the magnitude, time scales and pathways of monthly water mass exchanges. This will provide the basis for understanding how the global water cycle is responding to climate variations on monthly and S-I timescales, and will provide insight into potential responses to longer-term global change.

Beyond the potential results described in this proposal, broader impacts of the research are that it will provide a new method for monitoring Earth system change, with implications for estimating global water availability, preparing for hydrologic and climatological extreme events, and for predicting hazards in coastal areas. The storage change and flux estimates we produce will also provide an important reality check and source of calibration/validation data for global climate modelers.